OPEN FILE REPORT 15-87

FEASIBILITY OF ECONOMIC ZINC, COPPER, SILVER, AND GOLD MINING IN THE PORCUPINE MINING AREA OF THE JUNEAU MINING DISTRICT, ALASKA

MINERALS AVAILABILITY PROGRAM

BUREAU OF MINES
UNITED STATES DEPARTMENT OF THE INTERIOR

FEASIBILITY OF ECONOMIC ZINC, COPPER, SILVER, AND GOLD MINING IN THE PORCUPINE MINING AREA OF THE JUNEAU MINING DISTRICT, ALASKA

By

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Bureau of Mines Open File Report

No patentable features are contained in this report.

FOREWORD

This Bureau of Mines open file report is one of a series produced in conjunction with an ongoing Bureau of Mines mining district project being conducted by the Division of Mineral Land Assessment (MLA). Order of magnitude economic feasibility studies were conducted on typical deposit types that occur in the Porcupine mining area of the Juneau Mining District to determine ore quantities and metal prices which would allow mineral deposits to be mineable.

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UNIT OF MEASURE ABBREVIATIONS USED IN THIS REPORT

cm	centimeter
g	gram
kg	kilogram
lb	pound
mt	metric ton
pct	percent
tr oz	troy ounce
yr	year

INTRODUCTION

This report is one of a series produced in conjunction with an ongoing Bureau of Mines mining district project being conducted by the Division of Mineral Land Assessment (MLA). Order of magnitude economic feasibility studies were conducted on typical deposit types that occur in the Porcupine mining area of the Juneau Mining District to determine ore quantities and metal prices which would allow mineral deposits to be mineable. Two determinants were addressed in this study: (1) the magnitude of reserve which would have to exist, and (2) the metal prices which would be necessary to make a deposit economically feasible to mine. The interrelation between these factors is shown graphically in this report.

In order to make these economic assessments for three mineral deposit types, existing mineral deposit information was used wherever possible. Mineral deposit grades and supporting background information were furnished by MLA personnel. Because detailed deposit characteristics such as depth, thickness, attitude, and volume have not been determined for the partially explored deposits used as examples in this study, assumptions were made on some deposit characteristics. Those assumptions are discussed at the beginning of each deposit characteristics section.

The geographic location of the Porcupine mining area is near Haines in Southeastern Alaska. Haines is located on tidewater near the north end of the inside passage of Southeastern Alaska. The Porcupine mining area has been mined for placer gold since the turn of the century. It is an area roughly bounded by the Tsirku River to the south and east, The Klehini River to the north, and the Alaska - British Columbia border to the west. Figure 1 shows the boundaries as used in the Juneau Mining District project. Access to the area is provided by an all-weather highway that connects Haines with the Alcan highway in Canada. The Alaska portion of the highway is paved. The port at Haines is suitable for landing small to medium quantities of seaborne freight. There is a small airstrip (VFR only) located north of Haines suitable for their aircraft.

The climate at the Porcupine area is drier and colder than much of Southeastern Alaska, but its climate is influenced by the same weather systems that drop substantial precipitation. Winters are cold, with temperatures averaging 8° to 31° F; summers are cool, with average temperatures of 42° to 69° F. Annual precipitation at 200 m elevation is 90 cm including more than 440 cm snow (1)[1].

1 Underlined numbers in parentheses refer to items in the list of references at the end of this report.

ECONOMIC MINE FEASIBILITY STUDIES

Economic feasibility studies for three mineral deposit types were conducted to establish the discounted cash flow return on investment (DCFROI). For the purposes of this report, a DCFROI of 15 pct is considered to be economic.

Capital and operating costs were calculated using the Bureau of Mines Cost Estimating System (CES). Power generation was assumed to be by diesel-electric generators at the mine site. Capital costs of generation equipment are included in the mine and mill capital costs, and are scaled to the mining rates. Alaska wage rates and cost adjustment factors were used to escalate costs from "lower 48" to Alaska costs. All costs used in this report are in January, 1984 U.S. dollars.

Cash flows were calculated using the Bureau of Mines MINSIM mine simulation computer program. Alaska tax parameters were used. A 20 yr mine life was assumed, with a 5 yr preproduction period. MINSIM program runs were made at several mine rates to determine the quantity of material necessary to produce positive cash flows at various metal prices. Results of MINSIM program runs are reported in the text at three sets of metal prices, which are based on an evaluation of historical metal values from 1975 to 1984. These prices are listed in table 1.

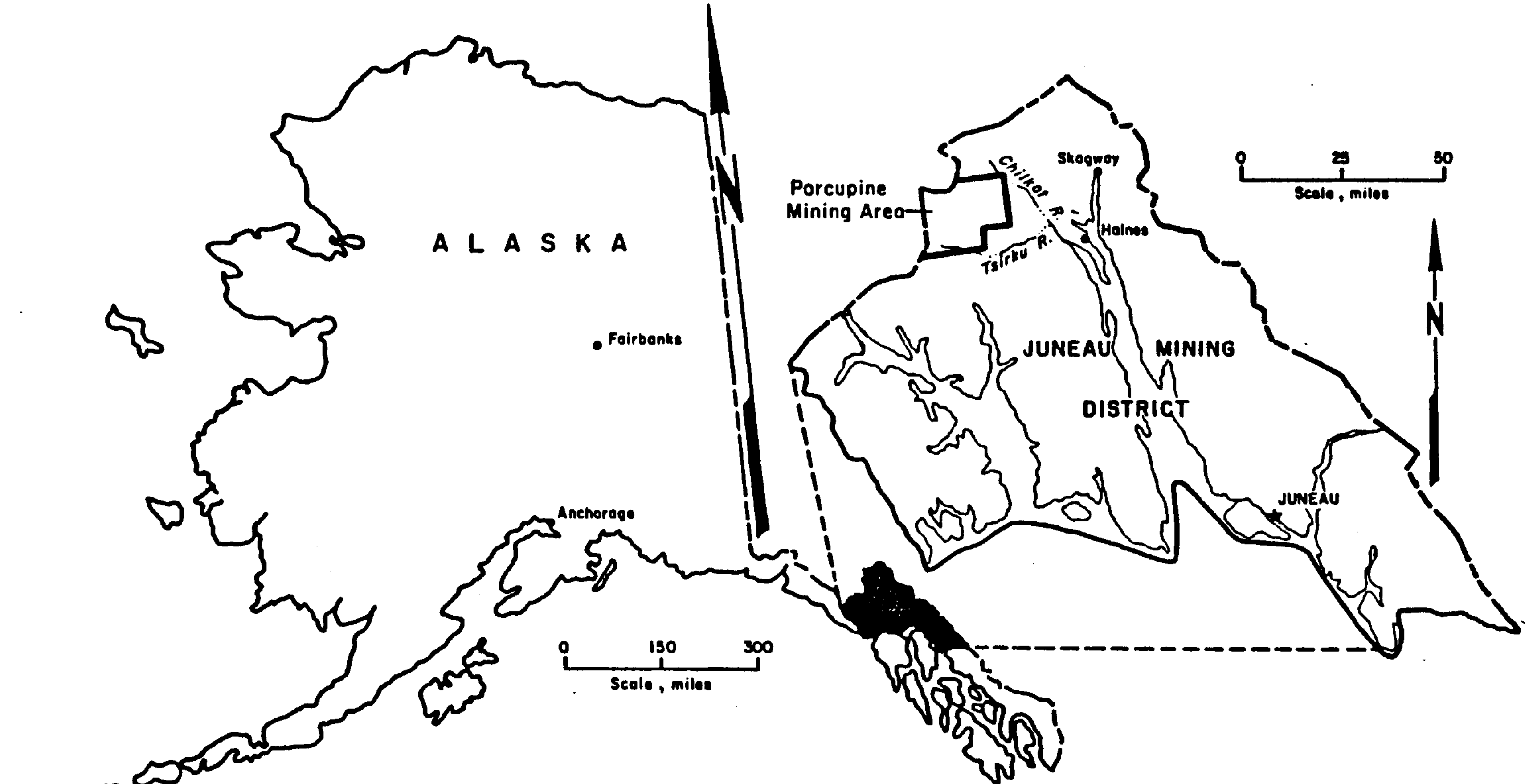

Figure 1. - Location of the Porcupine mining area.

TABLE 1. - Metal prices used in financial evaluations, dollars per unit.

Commodity	Low	Medium	High	Unit
Gold......	200	310	585	tr oz
Silver....	4.35	5.90	23.00	tr oz
Copper....	0.27	0.68	1.10	lb
Zinc......	.30	.37	0.44	lb

Graphs were prepared for each of the mine types which relate recoverable metal value (RMV) to DCFROI. RMV is the combined dollar value of all salable products from a given mineral deposit expressed in \$/mt. RMV was used to reduce the individual effects of commodity grades, recoveries, and metal prices to a common base so that a single curve relating ore value of the deposit to DCFROI could be created. The equation used in calculating RMV for a deposit is:

$$\sum_{i=1}^{n} G_i R_i S_i V_i,$$

where G_i = mill feed grade of commodity i,
R_i = mill recovery of commodity i,
S_i = smelter recovery of commodity i,
V_i = \$/unit of commodity i,
and n = total number of commodities.

For example, the RMV for a gold ore with a grade of 15.55 g/mt, 80 pct mill recovery, 99 pct smelter recovery, and a gold price of \$430/tr oz (\$13.83/g) is:

(15.55 g/mt)(0.8)(0.99)(\$13.83/g) = \$170.32/mt.

By calculating the RMV for a deposit type and using the graph for the appropriate mining method, the DCFROI can be estimated.

Massive Sulfide Deposit

A massive sulfide deposit similar to the Mount Henry Clay deposit(2) was evaluated using three mining methods: cut and fill, longhole, and open pit. The deposit at Mount Henry Clay is insufficiently explored to attempt a detailed description of deposit geometry, so several potential mining methods were described. Grade of the deposit was provided by MLA personnel based on assays of samples obtained during previous investigations: 25 pct zinc, 1 pct copper, 68.6 g/mt silver. Construction of a 15 km access road would be necessary to exploit the deposit. For the purpose of this exercise, mine recovery was fixed at 100 pct. Mill recoveries were assumed to be 90 pct for zinc, 80 pct for copper, and 50 pct for silver. Two concentrates would be produced by conventional froth flotation methods; a zinc concentrate containing 52 pct zinc and 79.2 g/mt silver, and a copper concentrate containing 22 pct copper. Transportation of concentrates was assumed to be by truck and barge to smelters in British Columbia, Canada.

Cut and Fill Mine

Costs were developed for an underground cut and fill mine for each of the following mining rates: 1,000, 2,000, 4,000, 6,000, and 8,000 mt/day. Cut and fill mining represents a medium-high cost underground mining method which might be used in the Porcupine area for massive sulfide mineral deposits that are steeply-dipping and have moderate-to-poor support characteristics. The mine would be operated at a production rate averaging 12 mt/manshift from an adit (no hoisting). Haulage would be by load-haul-dump vehicles and rear-dump trucks. After ore removal, stopes would be filled with classified mill tailings. Mine and mill costs are summarized in the appendix.

For this mining method, positive DCFROIs were produced only at high metal prices. Table 2 represents the results of MINSIM program runs for this mining method at different mining rates and metal prices.

TABLE 2. - Percent DCFROI produced by cut and fill mining - massive sulfide deposit.

Mining rate, mt/day	DCFROI at (metal prices) (low)	(medium)	(high)
1,000	0	0	2.5
2,000	0	0	11.8
4,000	0	0	16.3
6,000	0	0	20.1
8,000	0	0	22.9

From table 2, it can be seen that a DCFROI which exceeds a 15 pct threshold is produced at a mining rate of 4,000 mt/day using high metal prices. A reserve of 26,400,000 mt (4,000 mt/day X 330 days/yr X 20 yr) would be necessary to produce a 16 pct DCFROI at high metal prices. Table 2 also shows that this mining method would be uneconomic for a massive sulfide deposit during periods of medium or low metal prices. Figure 2 graphically exhibits the relationship of RMV to DCFROI for this deposit type using a cut and fill mining method.

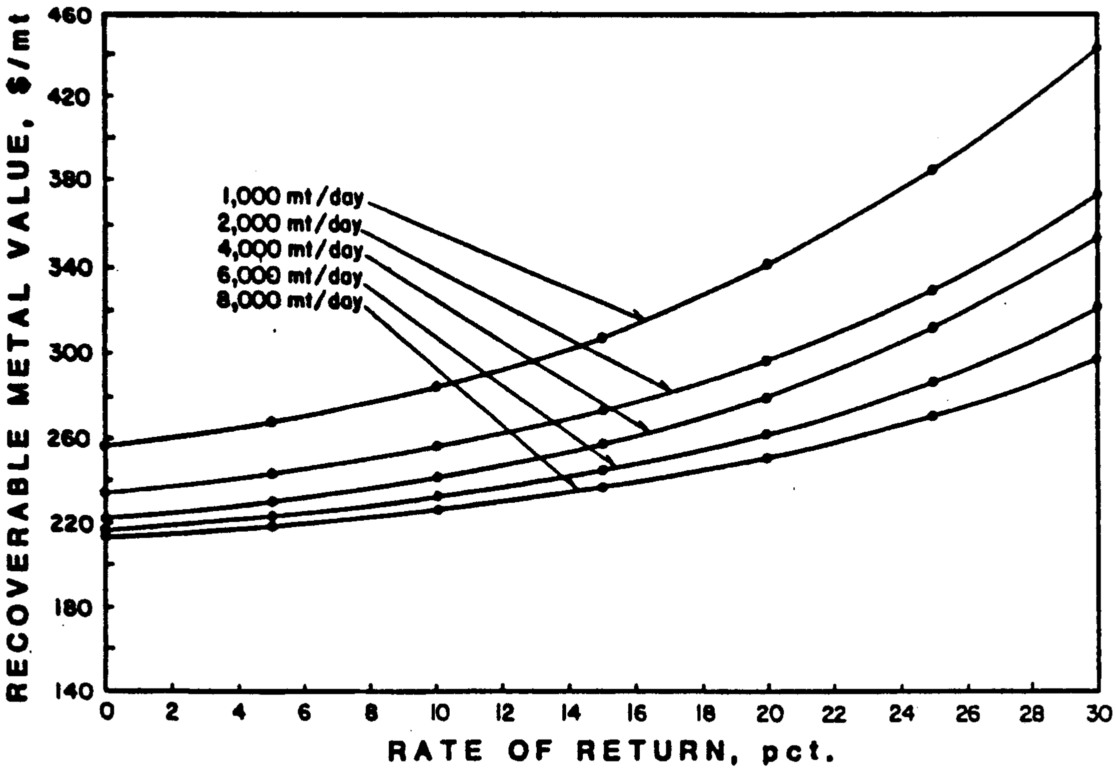

FIGURE 2. - Diagram illustrating the effects of recoverable metal value on rate of return, cut and fill mine, massive sulfide deposit.

Longhole Stope Mine

Costs were developed for an underground mine using longhole stoping methods for each of the following mining rates: 1,000, 2,000, 4,000, 6,000, and 8,000 mt/day. Longhole stoping is a medium-cost mining method which represents the least expensive underground mining method possible for a deposit in the Porcupine area with steeply-dipping ore zones, variable thickness, relatively competent support characteristics, and fairly uniform ore grade. Mine layout and haulage would be similar to the previous cut and fill example. Mine and mill costs are summarized in the appendix.

For this mining method, positive DCFROIs were produced at medium and high metal prices. Table 3 represents the results of MINSIM program runs for this mining method at different mining rates and metal prices.

TABLE 3. - Percent DCFROI produced by longhole stope mining - massive sulfide deposit.

Mining rate, mt/day	DCFROI at (metal prices) (low)	(medium)	(high)
1,000	0	0	11.2
2,000	0	0	18.4
4,000	0	0	21.5
6,000	0	0	25.3
8,000	0	9.1	27.8

From table 3, it can be seen that a DCFROI which exceeds a 15 pct threshold is produced at a mining rate of 2,000 mt/day using high metal prices. A reserve of 13,200,000 mt (2,000 mt/day X 330 days/yr X 20 yr) would be necessary to produce an 18 pct DCFROI at high metal prices. Table 3 also shows that this mining method would be uneconomic for a massive sulfide deposit during periods of medium or low metal prices, although a marginally economic DCFROI of 9 pct could be produced at a mining rate of 8,000 mt/day using medium metal prices. Figure 3 graphically exhibits the relationship of RMV to DCFROI for this deposit type using a longhole stoping mining method.

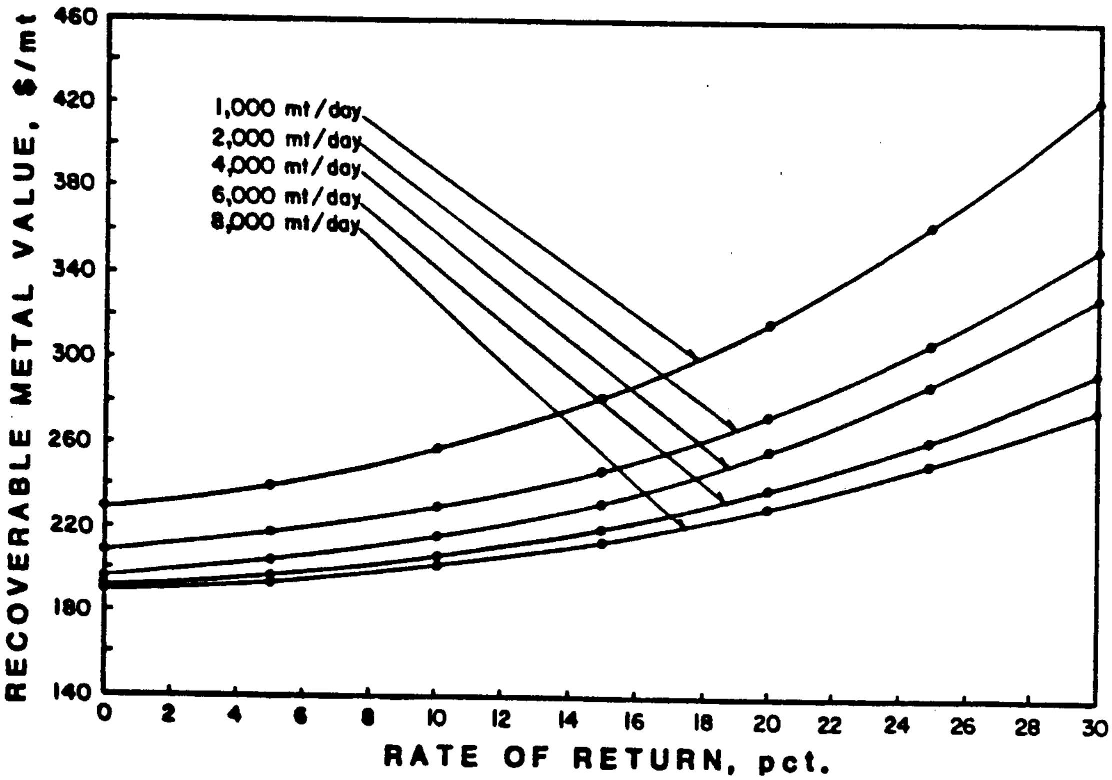

FIGURE 3. - Diagram illustrating the effects of recoverable metal value on rate of return, longhole stope mine, massive sulfide deposit.

Open Pit Mine

Costs were developed for a surface mine using open pit mining methods for each of the following mining rates: 1,000, 2,000, 4,000, 6,000, and 8,000 mt/day. Open pit mining is the lowest-cost mining method possible for a massive sulfide deposit in the Porcupine area. This mining method requires a massive or thickly-bedded deposit with a favorable waste-to-ore ratio. Assumptions used in this evaluation include a 2:1 waste-to-ore ratio, multiple benches averaging 15 m in height, excavation of ore by front-loaders, and ore haulage for a distance of 5 km using rear-dump trucks. Waste haulage would also be by rear-dump trucks. Other parameters vary depending on the mining rate. Pit depth ranges from 60 m for a 1,000 mt/day mine to 120 m for an 8,000 mt/day mine. Preproduction stripping ranges from 120,000 mt to 480,000 mt depending on the mining rate. Percussion drills would be used for ore and waste blasthole drilling for mines of 1,000 mt/day and 2,000 mt/day capacity, whereas a combination of percussion and rotary drills would be used for mines of 4,000 mt/day and greater capacity. Front-loaders would be used for excavating waste in mines of 1,000 mt/day and 2,000 mt/day capacity. Electrical shovels would be used for waste excavation in mines of 4,000 mt/day or greater capacity. Mine and mill costs are summarized in the appendix.

For this mining method, positive DCFROIs were produced at low, medium, and high metal prices. Table 4 represents the results of MINSIM program runs for this mining method at different mining rates and metal prices.

TABLE 4. - Percent DCFROI produced by open pit mining - massive sulfide deposit.

Mining rate, mt/day	DCFROI at (metal prices) (low)	(medium)	(high)
1,000	0	0	15.7
2,000	0	5.7	22.6
4,000	0	16.4	28.7
6,000	2.8	20.6	33.4
8,000	6.3	23.4	36.7

From table 4, it can be seen that a DCFROI which exceeds a 15 pct threshold is produced at a mining rate of 4,000 mt/day using medium metal prices. A reserve of 26,400,000 mt (4,000 mt/day X 330 days/yr X 20 yr) would be necessary to produce a 16 pct DCFROI at medium metal prices. A reserve of 6,600,000 mt (1,000 mt/day X 330 days/yr X 20 yr) would be necessary to produce a 15 pct DCFROI at high metal prices. Table 4 also shows that this mining method would be uneconomic for a massive sulfide deposit during periods of low metal prices. Figure 4 graphically exhibits the relationship of RMV to DCFROI for this deposit type using an open pit mining method.

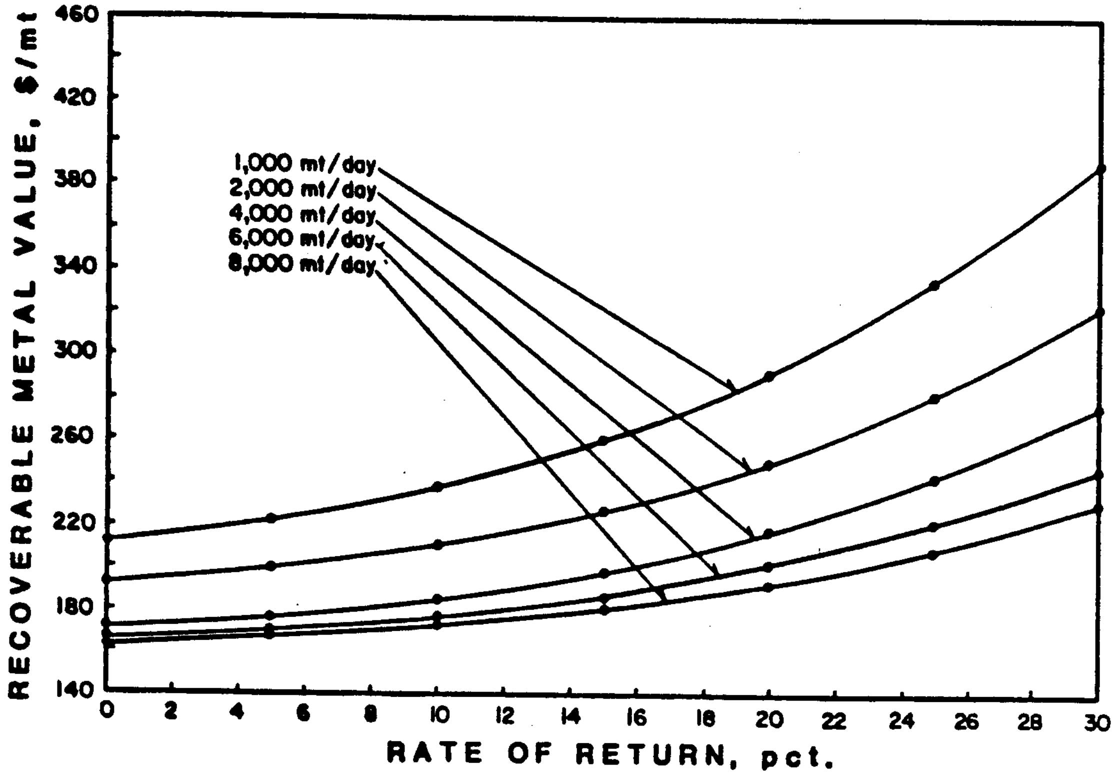

FIGURE 4. - Diagram illustrating the effects of recoverable metal value on rate of return, open pit mine, massive sulfide deposit.

Vein Gold Deposit

Evaluation of a vein gold deposit similar to deposits along McKinley Creek(3) was evaluated using an underground overhand stoping mining method. Veins are assumed to average 2 m in width, be fairly continuous, and dip very steeply. Grade of the deposit was provided by MLA personnel: 17.1 g/mt gold. For the purpose of this study, mine recovery was fixed at 100 pct. Mill recovery was assumed to be 90 pct. A gold product would be produced using gravity and amalgamation methods. Prices are assumed to be FOB mine.

Overhand Stope Mine

Costs were developed for an underground overhand stope mine for each of the following mining rates: 100, 200, and 400 mt/day. An adit-operated overhand stope mining method with rail haulage represents a low cost underground mining method which might be used in the Porcupine area for vein gold mineral deposits. Costs for rock bolting and square-sets in areas with weak support characteristics were considered. Mine and mill costs are summarized in the appendix.

For this mining method, positive DCFROIs were produced at low, medium, and high metal prices. Table 5 represents the results of MINSIM program runs for this mining method at different mining rates and metal prices.

TABLE 5. - Percent DCFROI produced by overhand stope mining - vein gold deposit.

Mining rate, mt/day	DCFROI at (metal prices) (low)	(medium)	(high)
100	0	6.0	28.2
200	0	19.0	36.5
400	1.0	24.2	41.6

From table 5, it can be seen that a DCFROI which exceeds a 15 pct threshold is produced at a mining rate of 200 mt/day using medium metal prices. A reserve of 1,320,000 mt (200 mt/day X 330 days/yr X 20 yr) would be necessary to produce a 19 pct DCFROI at medium metal prices. A reserve of considerably less than 660,000 mt (100 mt/day X 330 days/yr X 20 yr) would be adequate to produce a 15 pct DCFROI at high metal prices.
Table 5 also shows that this mining method would be uneconomic for a vein gold deposit during periods of low metal prices unless the deposit size was considerably larger than 2,640,000 mt (400 mt/day X 330 days/yr X 20 yr). Figure 5 graphically exhibits the relationship of RMV to DCFROI for this deposit type using an overhand stope mining method.

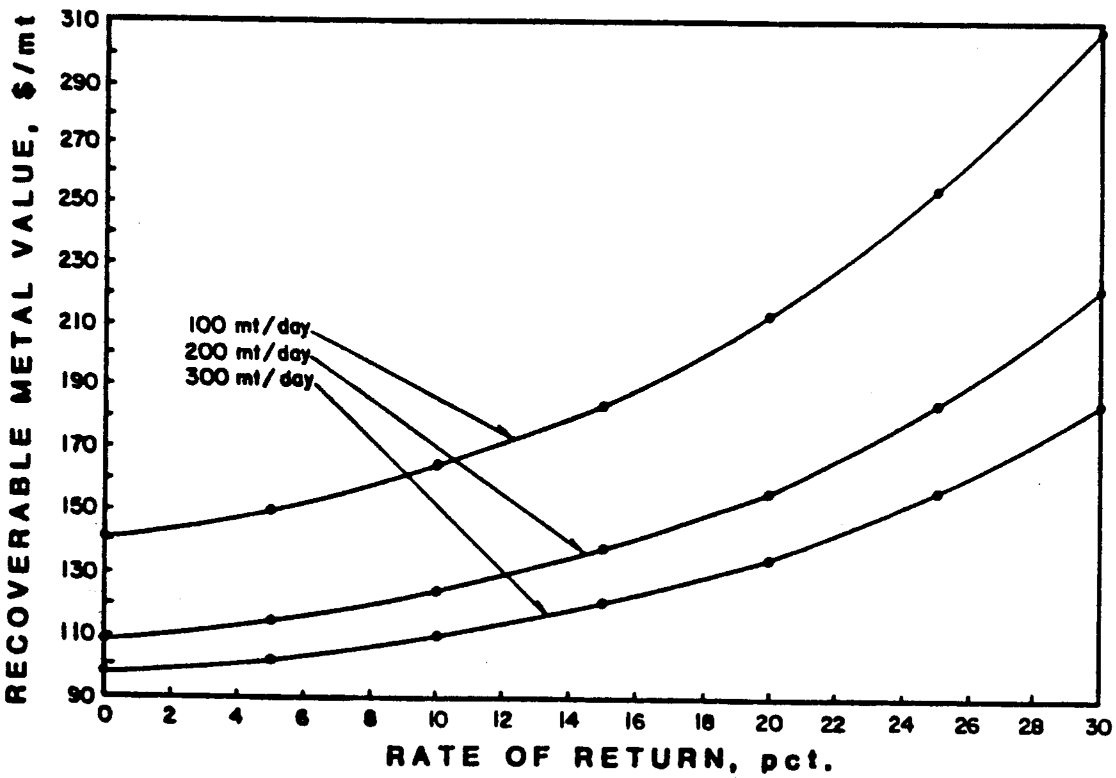

FIGURE 5. - Diagram illustrating the effects of recoverable metal value on rate of return, overhand stope mine, vein gold deposit.

Disseminated Gold Deposit

Evaluation of a disseminated or stockwork gold deposit similar to deposits in the Porcupine area was undertaken using a surface open pit mining method. Grade of the deposit was provided by MLA personnel: 1.71 g/mt gold. For the purpose of this study, mine recoveries were fixed at 100 pct. Mill recovery was assumed to be 90 pct. A gold product would be produced by gravity and amalgamation methods. Prices are assumed to be FOB mine.

Open Pit Mine

Costs were developed for a surface mine using open pit mining methods for each of the following mining rates: 1,000, 2,000, 4,000, 6,000, and 8,000 mt/day. Open pit mining is the lowest-cost mining method possible for a gold deposit of this type in the Porcupine area. No waste rock would be mined. A 5 km access road would be required. Ore removal would be by percussion blasthole drilling, excavation of blasted ore by front-loaders, and haulage by rear-dump trucks for a distance of 1 km to the mill. Pit depth would depend on the mining rate scenario, and vary from 30 m at a 1,000 mt/day mining rate to 60 m at an 8,000 mt/day mining rate. Mine and mill costs are summarized in the appendix.

For this mining method, positive DCFROIs were produced at medium and high metal prices. Table 6 represents the results of MINSIM program runs for this mining method at different mining rates and metal prices.

TABLE 6. - Percent DCFROI produced by open pit mining - disseminated gold deposit.

Mining rate, mt/day	DCFROI at (metal prices) (low)	(medium)	(high)
1,000	0	0	24.9
2,000	0	0	47.4
4,000	0	0	61.0
6,000	0	23.0	67.1
8,000	0	33.1	71.2

From table 6, it can be seen that a DCFROI which exceeds a 15 pct threshold is produced at a mining rate of 6,000 mt/day using medium metal prices. A reserve of 39,600,000 mt (6,000 mt/day X 330 days/yr X 20 yr) would be necessary to produce a 23 pct DCFROI at medium metal prices. A reserve of 6,600,000 mt (1,000 mt/day X 330 days/yr X 20 yr) would be necessary to produce a 25 pct DCFROI at high metal prices. This indicates that an open pit mining method could be used on deposits much smaller than 6,600,000 mt during periods of high gold prices. Table 6 also shows that this mining method would be uneconomic for a disseminated gold deposit during periods of low metal prices. Figure 6 graphically exhibits the relationship of RMV to DCFROI for this deposit type using an open pit mining method.

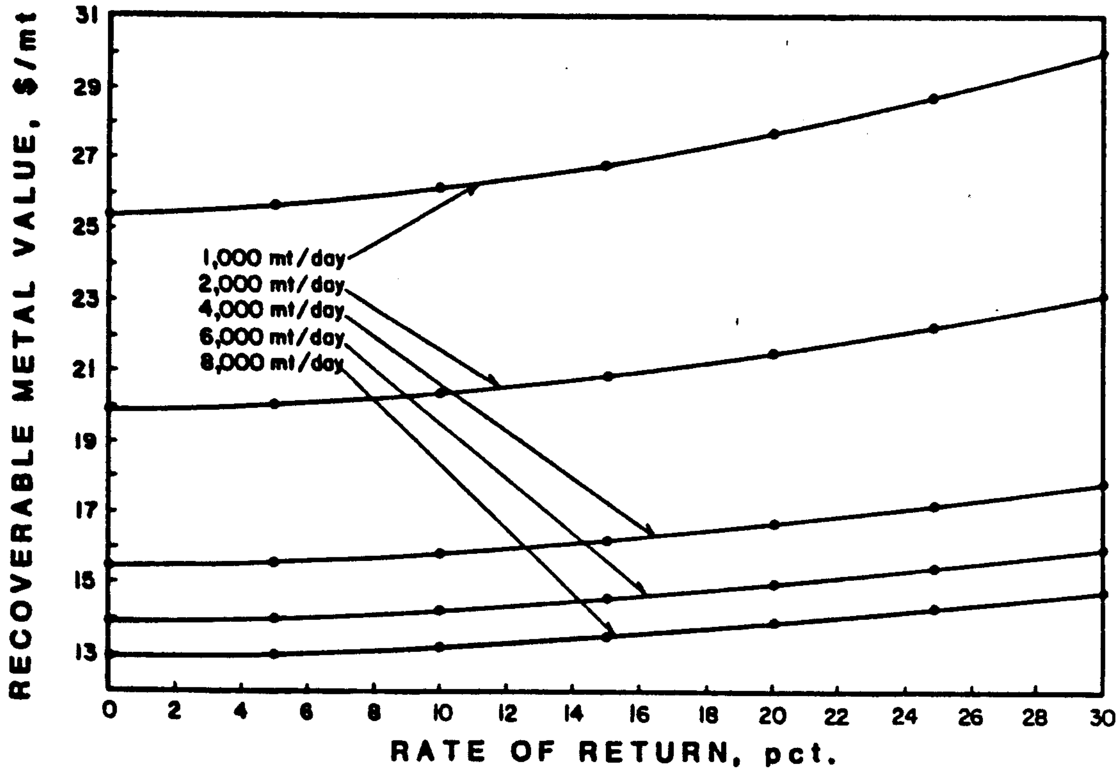

FIGURE 6. - Diagram illustrating the effects of recoverable metal value on rate of return, open pit mine, vein gold deposit.

CONCLUSIONS

This project resulted in the creation of 22 separate mine plans for which cost information was estimated. These are presented in tabular form in the appendix. A MINSIM program was run for each of the 22 mine plans at three sets of metal prices, for a total of 66 separate program runs. Results of those program runs using different deposit types, mining methods, mining rates, and metal prices indicate that factors such as deposit grade, size, and mining method affected profitability to a great extent. However, metal price changes had a much greater effect on the economics of mining operations. All of the mining scenarios used in this study were unprofitable to marginally profitable if low metal prices were assumed. With medium metal prices, several of the scenarios were economical. High metal prices ensured a profitable mine in most of the scenarios except when expensive cut and fill mining methods were used on a smaller (less than 4,000 mt/day) massive sulfide deposit.

In order to produce graphs showing the profitability of the different mining methods and mineral deposits versus RMV, a total of 161 MINSIM program runs were necessary. The effects of economy of scale are readily apparent when viewing the graphs. The major advantage of the graphs is that RMVs can be calculated by the reader using his (her) metal prices, mill recovery, and refinery recoveries as input; profitability of a specific mine type at several mining rates can then be read from the appropriate graph.

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2. Still, J. C. Stratiform Massive Sulfide Deposits of the Mt. Henry Clay Area, Southeast Alaska. BuMines OFR 118-84, 1984, 65 pp.

3. Still, J. C. Stream Sediment, Float, and Bedrock Sampling in the Porcupine Mining Area, Southeast Alaska. BuMines OFR 173-84, 1984, 6 pp.

APPENDIX--Detailed Cost Information

TABLE A-1. - Massive sulfide deposit smelter and transportation costs.

Category	Cost/mt	Beginning year	Ending year
Copper Smelter.	$275.91	1991	2010
Zinc Smelter...	271.22	1991	2010
Transportation.	17.36	1991	2010

TABLE A-2. - Underground cut and fill capital and operating costs, 1,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 4,550,300.00/yr	1986	1988
Acquisition.....	1,000,000.00/yr	1986	1988
Development.....	1,530,900.00/yr	1986	1990
Mine plant......	1,543,500.00/yr	1986	1990
Mine equipment..	4,890,100.00/yr	1989	1990
Mill............	8,643,800.00/yr	1988	1990
Working capital.	6,742,800.00/yr	1991	1991
Mine operating cost...........	82.97/mt	1991	2010
Mill operating cost...........	29.41/mt	1991	2010

TABLE A-3. - Underground cut and fill capital and operating costs, 2,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 8,217,000.00/yr	1986	1988
Acquisition.....	1,000,000.00/yr	1986	1988
Development.....	1,743,000.00/yr	1986	1990
Mine plant......	2,193,600.00/yr	1986	1990
Mine equipment..	8,579,800.00/yr	1989	1990
Mill............	12,085,700.00/yr	1988	1990
Working capital.	11,242,000.00/yr	1991	1991
Mine operating cost...........	71.78/mt	1991	2010
Mill operating cost...........	21.91/mt	1991	2010

TABLE A-4. - Underground cut and fill capital and operating costs, 4,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,383,600.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	3,449,900.00/yr	1986	1990
Mine plant......	3,628,100.00/yr	1986	1990
Mine equipment..	16,565,400.00/yr	1989	1990
Mill............	19,400,300.00/yr	1988	1990
Working capital.	19,430,400.00/yr	1991	1991
Mine operating cost...........	64.13/mt	1991	2010
Mill operating cost...........	16.83/mt	1991	2010

TABLE A-5. - Underground cut and fill capital and operating costs, 6,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,383,600.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	5,127,800.00/yr	1986	1990
Mine plant......	4,698,900.00/yr	1986	1990
Mine equipment..	21,134,000.00/yr	1989	1990
Mill............	23,838,900.00/yr	1988	1990
Working capital.	27,550,800.00/yr	1991	1991
Mine operating cost...........	61.91/mt	1991	2010
Mill operating cost...........	14.62/mt	1991	2010

TABLE A-6. - Underground cut and fill capital and operating costs, 8,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,383,600.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	6,809,400.00/yr	1986	1990
Mine plant......	5,639,000.00/yr	1986	1990
Mine equipment..	24,240,500.00/yr	1989	1990
Mill............	27,780,000.00/yr	1988	1990
Working capital.	35,414,400.00/yr	1991	1991
Mine operating cost...........	60.47/mt	1991	2010
Mill operating cost...........	13.31/mt	1991	2010

TABLE A-7. - Underground longhole stope capital and operating costs, 1,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 4,550,300.00/yr	1986	1988
Acquisition.....	1,000,000.00/yr	1986	1988
Development.....	1,530,900.00/yr	1986	1990
Mine plant......	1,543,500.00/yr	1986	1990
Mine equipment..	4,890,100.00/yr	1989	1990
Mill............	8,643,800.00/yr	1988	1990
Working capital.	5,065,800.00/yr	1991	1991
Mine operating cost...........	55.02/mt	1991	2010
Mill operating cost...........	29.41/mt	1991	2010

TABLE A-8. - Underground longhole stope capital and operating costs, 2,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 8,217,000.00/yr	1986	1988
Acquisition.....	1,000,000.00/yr	1986	1988
Development.....	1,743,000.00/yr	1986	1990
Mine plant......	2,193,600.00/yr	1986	1990
Mine equipment..	8,579,800.00/yr	1989	1990
Mill............	12,085,700.00/yr	1988	1990
Working capital.	8,067,600.00/yr	1991	1991
Mine operating cost...........	45.32/mt	1991	2010
Mill operating cost...........	21.91/mt	1991	2010

TABLE A-9. - Underground longhole stope capital and operating costs, 4,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,383,600.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	3,449,900.00/yr	1986	1990
Mine plant......	3,628,100.00/yr	1986	1990
Mine equipment..	16,565,400.00/yr	1989	1990
Mill............	19,400,300.00/yr	1988	1990
Working capital.	13,420,800.00/yr	1991	1991
Mine operating cost...........	39.09/mt	1991	2010
Mill operating cost...........	16.83/mt	1991	2010

TABLE A-10. - Underground longhole stope capital and operating costs, 6,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,383,600.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	5,127,800.00/yr	1986	1990
Mine plant......	4,698,900.00/yr	1986	1990
Mine equipment..	21,134,000.00/yr	1989	1990
Mill............	23,838,900.00/yr	1988	1990
Working capital.	18,820,800.00/yr	1991	1991
Mine operating cost...........	37.66/mt	1991	2010
Mill operating cost...........	14.62/mt	1991	2010

TABLE A-11. - Underground longhole stope capital and operating costs, 8,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,383,600.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	6,809,400.00/yr	1986	1990
Mine plant......	5,639,000.00/yr	1986	1990
Mine equipment..	24,240,500.00/yr	1989	1990
Mill............	27,780,000.00/yr	1988	1990
Working capital.	35,414,400.00/yr	1991	1991
Mine operating cost...........	36.77/mt	1991	2010
Mill operating cost...........	13.31/mt	1991	2010

TABLE A-12. - Surface open pit capital and operating costs, 1,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 4,717,000.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	238,500.00/yr	1986	1990
Mine plant......	1,685,100.00/yr	1986	1990
Mine equipment..	2,792,700.00/yr	1989	1990
Mill............	8,589,600.00/yr	1988	1990
Working capital.	4,159,200.00/yr	1991	1991
Mine operating cost...........	39.91/mt	1991	2010
Mill operating cost...........	29.41/mt	1991	2010

TABLE A-13. - Surface open pit capital and operating costs, 2,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 8,383,700.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	358,700.00/yr	1986	1990
Mine plant......	2,279,000.00/yr	1986	1990
Mine equipment..	3,944,100.00/yr	1989	1990
Mill............	12,031,700.00/yr	1988	1990
Working capital.	6,256,800.00/yr	1991	1991
Mine operating cost...........	30.23/mt	1991	2010
Mill operating cost...........	21.91/mt	1991	2010

TABLE A-14. - Surface open pit capital and operating costs, 4,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,550,300.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	142,900.00/yr	1986	1990
Mine plant......	3,150,200.00/yr	1986	1990
Mine equipment..	5,859,200.00/yr	1989	1990
Mill............	17,387,300.00/yr	1988	1990
Working capital.	7,778,400.00/yr	1991	1991
Mine operating cost...........	15.58/mt	1991	2010
Mill operating cost...........	16.03/mt	1991	2010

TABLE A-15. - Surface open pit capital and operating costs, 6,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,550,300.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	185,100.00/yr	1986	1990
Mine plant......	3,770,000.00/yr	1986	1990
Mine equipment..	7,929,000.00/yr	1989	1990
Mill............	23,785,100.00/yr	1988	1990
Working capital.	10,227,600.00/yr	1991	1991
Mine operating cost...........	13.79/mt	1991	2010
Mill operating cost...........	13.90/mt	1991	2010

TABLE A-16. - Surface open pit capital and operating costs, 8,000 mt/day massive sulfide mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$17,550,300.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	185,100.00/yr	1986	1990
Mine plant......	4,352,600.00/yr	1986	1990
Mine equipment..	9,862,900.00/yr	1989	1990
Mill............	29,638,200.00/yr	1988	1990
Working capital.	12,465,600.00/yr	1991	1991
Mine operating cost...........	12.66/mt	1991	2010
Mill operating cost...........	12.63/mt	1991	2010

TABLE A-17. - Underground overhand stope capital and operating costs, 100 mt/day vein gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 522,900.00/yr	1986	1988
Acquisition.....	333,300.00/yr	1986	1988
Development.....	43,300.00/yr	1986	1990
Mine plant......	201,900.00/yr	1986	1990
Mine equipment..	100,200.00/yr	1989	1990
Mill............	290,000.00/yr	1988	1990
Working capital.	810,300.00/yr	1991	1991
Mine operating cost...........	101.43/mt	1991	2010
Mill operating cost...........	33.62/mt	1991	2010

TABLE A-18. - Underground overhand stope capital and operating costs, 200 mt/day vein gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 678,300.00/yr	1986	1988
Acquisition.....	333,300.00/yr	1986	1988
Development.....	86,600.00/yr	1986	1990
Mine plant......	307,100.00/yr	1986	1990
Mine equipment..	247,000.00/yr	1989	1990
Mill............	445,300.00/yr	1988	1990
Working capital.	1,249,300.00/yr	1991	1991
Mine operating cost...........	79.63/mt	1991	2010
Mill operating cost...........	24.48/mt	1991	2010

TABLE A-19. - Underground overhand stope capital and operating costs, 400 mt/day vein gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 989,000.00/yr	1986	1988
Acquisition.....	500,000.00/yr	1986	1988
Development.....	173,300.00/yr	1986	1990
Mine plant......	478,400.00/yr	1986	1990
Mine equipment..	406,500.00/yr	1989	1990
Mill............	684,300.00/yr	1988	1990
Working capital.	2,270,000.00/yr	1991	1991
Mine operating cost...........	76.42/mt	1991	2010
Mill operating cost...........	18.16/mt	1991	2010

TABLE A-20. - Surface open pit capital and operating costs, 1,000 mt/day disseminated gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 1,961,200.00/yr	1986	1988
Acquisition.....	1,000,000.00/yr	1986	1988
Development.....	34,600.00/yr	1986	1990
Mine plant......	858,600.00/yr	1986	1990
Mine equipment..	1,157,700.00/yr	1989	1990
Mill............	8,690,500.00/yr	1988	1990
Working capital.	1,516,800.00/yr	1991	1991
Mine operating cost...........	11.95/mt	1991	2010
Mill operating cost...........	13.33/mt	1991	2010

TABLE A-21. - Surface open pit capital and operating costs, 2,000 mt/day disseminated gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 2,794,500.00/yr	1986	1988
Acquisition.....	1,000,000.00/yr	1986	1988
Development.....	34,600.00/yr	1986	1990
Mine plant......	1,170,600.00/yr	1986	1990
Mine equipment..	1,635,000.00/yr	1989	1990
Mill............	12,776,000.00/yr	1988	1990
Working capital.	2,380,800.00/yr	1991	1991
Mine operating cost...........	9.37/mt	1991	2010
Mill operating cost...........	10.47/mt	1991	2010

TABLE A-22. - Surface open pit capital and operating costs, 4,000 mt/day disseminated gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 3,627,900.00/yr	1986	1988
Acquisition.....	1,333,300.00/yr	1986	1988
Development.....	34,600.00/yr	1986	1990
Mine plant......	1,852,800.00/yr	1986	1990
Mine equipment..	2,309,100.00/yr	1989	1990
Mill............	19,436,200.00/yr	1988	1990
Working capital.	3,712,800.00/yr	1991	1991
Mine operating cost...........	7.24/mt	1991	2010
Mill operating cost...........	8.23/mt	1991	2010

TABLE A-23. - Surface open pit capital and operating costs, 6,000 mt/day disseminated gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 3,627,900.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	50,000.00/yr	1986	1990
Mine plant......	2,324,600.00/yr	1986	1990
Mine equipment..	2,825,700.00/yr	1989	1990
Mill............	27,308,800.00/yr	1988	1990
Working capital.	5,000,400.00/yr	1991	1991
Mine operating cost...........	6.36/mt	1991	2010
Mill operating cost...........	7.53/mt	1991	2010

TABLE A-24. - Surface open pit capital and operating costs, 8,000 mt/day disseminated gold mine.

Category	Cost	Beginning year	Ending year
Exploration.....	$ 3,627,900.00/yr	1986	1988
Acquisition.....	1,666,700.00/yr	1986	1988
Development.....	50,000.00/yr	1986	1990
Mine plant......	2,831,200.00/yr	1986	1990
Mine equipment..	3,261,000.00/yr	1989	1990
Mill............	34,814,100.00/yr	1988	1990
Working capital.	6,201,600.00/yr	1991	1991
Mine operating cost...........	5.81/mt	1991	2010
Mill operating cost...........	7.11/mt	1991	2010